Future of Berkeley Lab Summary

Department of Energy Institutional Review

During the next two decades Lawrence Berkeley National Laboratory will continue to create and sustain scientific programs that provide an invaluable national asset for the Department of Energy (DOE) and the Office of Science (SC). We will manage our diverse scientific portfolio by exploiting the interdependence of our programs in support of the DOE Strategic Plan, the SC *Strategic Plan* and *Facilities for the Future of Science* roadmaps. The Laboratory will serve a growing SC user community with scientific and engineering capabilities that advance frontiers of nanoscience, genomics, chemistry, physics, geosciences, computing, and environmental and energy research.

Berkeley Lab's future lies at the intersection of these scientific frontiers—where the physical and life sciences connect, where the ultra-small is unified with the ultra-large, and where computational science adds a new dimension to scientific inquiry. These connections are a source of creativity and innovation for DOE science. We will lay the foundation for improving energy security, the environment, and the health of our citizens, and for understanding the nature of Earth in the cosmos.

Berkeley Lab will continue to be an incubator of new scientific ideas for the national laboratory complex, working in partnership with other institutions to develop these ideas to their fullest potential. We expect breakthrough discoveries to emanate from these ideas and from the new generation of scientific tools that we envision. Our research benefits all SC Program Offices, and those of the Office of Energy Efficiency and Renewable Energy, the Office of Fossil Energy, and the Office of Civilian Radioactive Waste Management. Following is a summary roadmap that addresses major scientific directions and identifies key next steps needed to overcome barriers to success.

Basic Energy Sciences

Berkeley Lab will advance the strategic goal to *Advance the Basic Sciences for Energy Independence* by further developing its core competencies in materials science, chemistry, energy biosciences and the geosciences. Basic Energy Sciences (BES) sponsored capabilities benefit many other Office of Science programs and the Energy Efficiency and Renewable Energy programs in fuel cells, hydrogen, and solid state lighting, as examples. A new focus is at the interface of biology and the physical sciences, gaining from the highly evolved information built into living systems and adapting these capabilities into materials and processes with high specificity and efficiency.

Berkeley Lab's materials sciences research will bring together the capabilities in solid state physics, surface science and catalysis, electronic materials, and other critical fields of research to address major scientific questions and technical challenges to tailor materials properties and understand materials systems. Berkeley Lab will continue to seek, predict, and control chemical reactions through programs in physical chemistry, combustion chemistry, advanced spectroscopy, theoretical chemistry and other chemistry areas. Berkeley labs research in photosynthesis will aim to harness sunlight with high efficiency and transform this energy into alternative fuels. Geosciences research will provide advanced methods for imaging and modeling the subsurface environment. Several key areas for future emphasis for BES programs are:

Molecular Foundry. By 2006, the Molecular Foundry will have been constructed at Berkeley Lab, ushering in a new era of interdisciplinary nanoscience research. This national user facility, based on a strong foundation in advanced materials research, will be dedicated to the discovery, characterization, understanding, and use of advanced materials and structures, and their integration into functional assemblies of organic and inorganic molecular components. New nanophotovoltaic and nanomotor systems are already

emerging. A “jump-start” program, initiated in advance of facility completion, is underway using temporary space and with limited funding. Ten full time dedicated Foundry scientists have been hired. Close to 20 user proposals involving over 40 users have been approved and work is beginning on nanoscience projects ranging from molecular biology to physics to nanofabrication to complex combinations of these fields. Building on understanding gained through nanostructured materials research, in the next decade a new program will emerge for Atom-by-Atom Synthesis. Synthesis will be accomplished by selecting and placing individual atoms in predetermined locations in complex materials, for example, doping nanocrystals by placing individual dopants at precise, rather than statistically determined positions. *Berkeley Lab is committed to the successful execution of the Molecular Foundry project, which is on scope, schedule, and budget and to the rapid expansion of the user program including involvement of industry, universities, and national laboratories.*

Advanced Light Source (ALS) Upgrades. To remain at the cutting edge in high-resolution spectroscopy and x-ray microscopy, and to exploit coherence, the ALS requires continuous current fill of the storage ring “top off mode” and the replacement of five insertion devices with nine new, narrow-gap, low-emittance undulators. The upgrade includes the installation of a small super-radiant synchrotron ring that will emit complementary infrared radiation many orders of magnitude brighter than current sources. *Berkeley Lab will work with SC to assess the schedule of the ALS upgrade, which is now a “far-term” project but has near-term user expectations.*

Transmission Electron Aberration-corrected Microscope (TEAM). The TEAM instrument, a top tier priority for the SC *Facilities for the Future of Science* roadmap, is being developed as a collaborative project of the five BES efforts in electron beam microcharacterization. Led by Berkeley Lab, TEAM will overcome limitations posed by current lens aberration to achieve 0.5-angstrom resolution in real-time with various contrast imaging techniques. The lens geometry allows high angle tilting for three-dimensional reconstruction, nanophase crystallography, in-situ manipulation, and atomic-column spectroscopy. *To advance this program, Mission Need has been submitted by BES, and with continued progress on R&D, the instrument will remain on track for commissioning in FY 2008.*

Biological and Environmental Research

Berkeley Lab will advance SC’s strategic goal to *Harness the Power of Our Living World* through quantitative biology, genomics, advanced imaging, biomolecular engineering and testing, and computational simulation. These programs will reveal the molecular mechanisms of living systems’ adaptation and response to their environment, utilize microbes for carbon sequestration and hydrogen production, and, in complementary partnership with the National Institutes of Health, will develop new methods to diagnose and treat disease. Much of this effort will leverage on the core capabilities in nuclear medicine, including the strong research programs in molecular biology, diagnostics imaging, and radiopharmaceuticals. We expect new advances to achieve comprehensive systems understanding of cellular and multicellular responses to environmental changes, such as low-level ionizing radiation.

Berkeley Lab’s environmental research programs will continue to address the major challenges of environmental restoration and global change. Environmental monitoring and analysis will address atmospheric, terrestrial, and subsurface processes, such as the development of instrumentation to study carbon cycling in the oceans and aerosols in the atmosphere to help model the heat balance of the earth. LBNL will continue to play a central role in the DOE's effort in carbon management and sequestration. As one of the DOE's seven regional centers of CO2 sequestration LBNL will have a broad based effort in terrestial sequestration, Ocean CO2 studies and geologic sequestration. Current efforts will be expanded to integrate the research findings to provide a total solution to carbon management. These are sponsored by OBER, BES, and Fossil Energy. Key programs for the future span scales from molecular and cellular systems to earth monitoring and simulation research:

Facility for the Characterization, Modeling, and Design of Microbial Behavior from Nanoscale Molecular Machines to Microbial Communities. Berkeley Lab proposes a facility to elucidate the assembly of macromolecular structures into microbial cells and to understand the responses of such systems to their environment. The Facility will provide the tools and capabilities to predict, control, and design molecules and biological assemblies. Co-location of current GTL-funded projects will take advantage of interdependence among research groups in functional genomics, metabolomics technology, applied environmental microbiology, and advanced computation, and will lead to the development of a suite of novel, often hybrid, technologies for imaging on scales from the atomic to whole cells and cellular systems. The program will deliver results by designing hydrogen-producing bacteria; developing protocols for large-scale, natural simulations of cellulose-degrading microbial populations; and predicting cellular capabilities and life-cycle strategies of newly sequenced organisms. *We will work with SC to expand computational standards and tools, and develop theoretical strength, expand the research core in bio-chemical engineering, pursue strategic partnerships between SC/NIH to develop innovative technologies and programs, and accelerate participation of universities and industry.*

Joint Genome Institute (JGI) Community Sequencing Program and Bioremediation Genomics. Sixty percent of the JGI's sequencing capacity, now over two billion basepairs/month, is being made available to the scientific community with the JGI reconfigured as a user facility. Through this Community Sequencing Program and its associated peer review process, scientific disciplines with fundamental questions in fields ranging from geochemistry to environmental ecology are beginning to access the high-throughput, cost-effective sequencing capacity and informatics capabilities at the JGI. A major new initiative of the JGI is the area of cataloging microbial diversity and performing gene surveys at DOE's most severe waste sites. Through the cataloging, and analysis of molecular ecologies at these sites, strategies for impacting bioremediation will be developed. *The JGI will work with OBER in coordinating microbial sequencing targets to decipher the properties and impact of individual microbes as well as the communities of microbes present at DOE's waste sites through an expanding bioremediation genomics initiative.*

Biotechnology Resource for Interdisciplinary Discovery and Genome Engineering (BRIDGE). Berkeley Lab proposes to leverage SC capabilities in multidisciplinary, quantitative biology to develop a deeper understanding of the biomolecular systems that enable cells, tissues, and organisms to function. The general features of the molecular complexes that control these systems are increasingly well established. However, the detailed components of these molecular systems are not adequately known, nor is it understood quantitatively how individual components interact in normal and disease states. Generating this body of knowledge is daunting because of the complexity of the interacting systems—ultimately, thousands of genes and gene products may be involved in processes such as growth, death, motility, DNA repair, secretion, and proteolysis. Berkeley Lab proposes to address these issues by developing a third-party funded facility committed to elucidation of the functions of interacting molecular systems and to test biomolecules that beneficially modulate these systems. These capabilities will depend on, and contribute to, SC's efforts in Genomics: GTL, genome sequencing, and low-dose radiation biology. *The Laboratory will nurture the support of the BRIDGE concept that has been demonstrated by the University of California (UC) San Francisco and Bay Area biotechnology firms. The Laboratory will pursue support for beneficial SC/NIH partnerships and close coupling with industry and universities.*

SECURE EARTH: Subsurface Energy and Environmental Science. Solutions to U.S. energy and environmental issues will require greatly increased understanding of earth and atmospheric processes in order to predict, protect, and utilize critical natural resources. Berkeley Lab's efforts will focus on cross-cutting geoscience research to address urgent problems in environmental remediation, CO_2 sequestration, fossil and geothermal energy, climate change, and nuclear energy through safe nuclear waste disposal. Focused field, laboratory, and modeling research will delineate subsurface fluid flow paths, and characterize and engineer them through geochemical and microbiological processes. Critical to the success will be: development and testing of nanosensors for use in earth systems; atomic-scale to pore-scale studies of physical, chemical, and biological properties and processes in heterogeneous materials; and advanced

computational modeling to simulate the complex geochemical, biological, and physical processes occurring in and above the earth. *Berkeley Lab will work with SC to develop this program built on strengths in Basic Energy Sciences, Biological and Environmental Research, and Advanced Scientific Computing Research.*

Fusion Energy Sciences

Berkley Lab will advance SC's strategic goal to *Bring the Power of the Stars to Earth* and to develop a strong high energy density physics research program. Berkeley Lab and the Heavy Ion Fusion Virtual National Laboratory collaboration are advancing inertial fusion energy research based on heavy ion drivers. Additionally, Berkeley Lab's capabilities in diagnostic neutral beams and Nb3Sn magnets can also enable the success of magnetic confinement research program at the **International Thermonuclear Experimental Reactor (ITER)**. Both of these programs will contribute to the success of SC's Fusion Energy Science research program.

A High Energy Density Physics (HEDP) User Facility. Heavy ions are excellent for studying high energy density physics by uniformly heating thin target plasmas with the peak energy deposited in a location near the target center. The primary challenge in exploiting these properties when creating high energy density matter and fusion ignition conditions is to compress the beam in time to durations short compared to the target disassembly time, while also focusing to a small spot to deposit high energy density. We will pursue these challenges with a 10-year objective of establishing the physics basis for a ~$50M-class heavy-ion accelerator capable of producing 1-10 eV solid density plasmas with sufficient uniformity and diagnostic resolution adequate to discriminate the predictions of various *ab initio* theories for strongly-coupled plasmas. Successful achievement of this objective will address the Office of Fusion Energy Sciences 10-year measure for inertial fusion energy/high energy density physics: *"With the help of experimentally validated theoretical and computer models, determine the physics limits that constrain the use of inertial fusion energy drivers in future key integrated experiments needed to resolve the scientific issues for inertial fusion energy and high energy density physics"*. In addition, such an accelerator-driven HEDP facility would represent an important step towards the long-term objective of heavy-ion-driven inertial fusion.

High Energy Physics

Berkeley Lab will advance SC's strategic goal to *Explore the Fundamental Interactions of Energy, Matter, Time, and Space* through targeted experimental programs supported by theory and computational simulation. Over the next two decades, our programs will reveal the nature of dark energy, dark matter, the origin of mass and matter-antimatter asymmetry, the mass of neutrinos, the dimensionality of space-time, and the structure of matter at the birth of the universe.

Joint Dark Energy Mission (JDEM). The path toward understanding, dark energy, the dominant component of the universe, is founded on a DOE/NASA Joint Dark Energy Mission. Berkeley Lab is leading this effort with a SuperNova/Acceleration Probe (SNAP) to measure dark energy by observing distant Type Ia supernovae spectra with a highly instrumented orbiting telescope. JDEM is a top priority of the SC *Facilities for the Future of Science* roadmap. The Laboratory will advance the precision photodetectors and instrumentation package into full mission readiness. *A key next step is for the Office of Science to work with NASA to sustain the priority for the Einstein Probes and the Joint Dark Energy Mission.*

Dark Matter and the Origin of Mass. The next generation of accelerator-based research will open an era where laboratory experiments shed light on some of the most profound mysteries of the universe. All indications point to dark matter particles existing at the TeV mass scale; the next generation of accelerators have the capability to explore this scale, uncover these new particles, and measure their properties in detail. Supersymmetric particles will likely be discovered at the LHC and precision studies of their properties will be a major focus of the Linear Collider program. In addition, the LHC will search for the Higgs boson,

thought to be the source of particle mass, and will provide data of enormous significance in improving our understanding of the fundamental properties of matter. Further experiments will be accomplished by upgrading the LHC in either luminosity or energy. When the TeV-scale linear collider (LC) is constructed, it will complete the picture by permitting the precise measurement of the properties of the Higgs bosons and other new particles. A continuing program in advanced detectors and computing infrastructure are crucial for these programs. Advanced accelerator technology will need continuous development to build and fully exploit the capability of these machines.

Accelerators for the Energy Frontier. Berkeley Lab's demonstration of laser-accelerated beams, with narrow energy spread in fields of ~100 GeV/meter, promises extremely high energy beams with short accelerator structures. Within a few years, we will demonstrate centimeter-scale plasma structures that accelerate high quality beams to multi-GeV energies. Compact, high energy beam sources already offer a new paradigm of a national user facility. The Mesoscale Laser User Facility will advance the scientific frontiers across the Office of Science in high energy density physics, in structural and dynamic studies with femtosecond hard X-rays and electron beam probes, and ultimately, in revolutionary prospects for multi—TeV high energy physics. The Laboratory will be active in the development of the **Linear Collider** in the mid term and of the **Super Neutrino Beam** in the far term. *To address the R&D needs, the Laboratory will require modest SC investments to make the next steps to centimeter structures and will work with SC to assure adequate facilities for the laser accelerator program.*

Nuclear Physics

Berkeley Lab will advance SC's strategic goal to *Explore Nuclear Matter from Quarks to the Stars* through experimental programs at the Laboratory and in partnership with other laboratories and universities. Over the next two decades, our programs will reveal the nature of the nucleon and nucleonic matter, including the evolution and properties of the quark-gluon plasma, the structure of stable nuclei and those at the limits of stability, and the properties of neutrinos.

Double Beta Decay. Berkeley Lab will sustain its leadership in non-accelerator-based nuclear physics, including the development of neutrino experiments worldwide and the Double Beta Decay experiments planned in the U.S. The Double Beta Decay Underground Detector experiments for understanding neutrino physics are a mid-term priority in SC plans and a key part of the NSF initiative to build a deep underground laboratory. Berkeley Lab is active in building collaborations that advance this experimental program.

Rare Isotope Accelerator (RIA). Berkeley Lab has played a leadership role in the development of the Rare Isotope Accelerator concept. Berkeley Lab will be an active participant in the construction and operation of the accelerator as well as the science program. Partnership agreements are being developed with the proposed candidate sites for the RIA facility. Our expertise in Electron Cyclotron Resonance (ECR) ion sources, front-end design, superconducting magnets, and Gamma-Ray Tracking detectors will be directly applicable to this project.

88-Inch Cyclotron. Berkeley Lab's 88-Inch Cyclotron has a critical national mission in the short term, and can form the basis of a cost-effective Stable Beams Facility in the RIA era.

RHIC Upgrades. Our heavy ion nuclear physics experimental and theoretical capabilities will make important contributions to RHIC II in the mid term and eRHIC in the far term.

Office of Advanced Scientific Computing Research

In order to ensure the highest performance computing and network resources SC has placed both the NERSC and ESnet upgrades as a high priority in the *Facilities for the Future of Science* roadmap. Berkeley Lab's thrust in computing is to serve the growing SC and national computational science community to deliver new scientific results through expanded capacity and network bandwidth. Berkeley Lab's mathematics, computer

science, and computational science programs will also provide seminal advances for the Office of Advanced Scientific Computing Research (OASCR) and will contribute to important applications for other SC programs. In particular, through the development and deployment of algorithms, software, tools, Berkeley Lab researchers funded under the SciDAC program will enhance the productivity of computational scientists, assure the more efficient utilization of Terascale platforms, and enhance collaborations across the DOE complex. *Berkeley Lab is working with SC to develop the framework and plans for the ESnet and NERSC upgrades, and with UC for a third-party funded computing building to house these facilities on the Laboratory campus.*

The Berkeley Lab mathematics and computer science research program has national prominence in the following four areas:

- Applied mathematics and numerical algorithms. The mathematics program will continue to lead the development of adaptive mesh refinement (AMR) techniques enabling the solution of larger, more complex computational problems. Level set methods and fast marching methods, numerical linear algebra techniques will also advance numeric simulation for many applications.
- Tools and software for advanced architecture platforms. Berkeley Lab makes important contributions in understanding the potential computer architecture advances for computational science and delivering innovative tools to exploit new technology. Research focuses on the evaluation, benchmarking, and innovative programming models and system software.
- Management and analysis of large scientific data. Terascale computers and new facilities will produce Petabytes of data, from both simulation and experiment. Berkeley Lab researchers investigate new methods for managing large datasets, extracting information with new algorithms, exploring new visualization techniques, and deploying these in national collaborations.
- Middleware and tools for distributed computing, networking, and grid computing. Computational science is collaborative and connects geographically distributed groups. Berkeley Lab leads research and development in methods and tools that will enable these collaborations in a qualitatively new way by improving access to remote instruments, data, computing resources, and optimizing network resources, while providing cybersecurity.

The capabilities provide a strong basis for moving scientific computing forward and strengthening the key scientific facilities initiatives for the future:

National Energy Research Scientific Computing (NERSC) Center Upgrade. NERSC is the premier open and unclassified computing facility for the Office of Science. An expanded computing capacity at NERSC is necessary for the growing complexity of SC research needs and for the expanding demands of the user community. The NERSC upgrade, which is a near-term priority for SC, will greatly benefit from new science-based computing architectures. NERSC has pioneered the concept of science-driven computer architectures. This approach will result in a significantly increased efficiency of the NERSC5 system, to be deployed in FY 2008. *We have worked closely with IBM to design a machine that better meets the needs of scientific applications, so that the upgrade will utilize a cost-effective, high-performance architecture. Specialized scientific extension enhancements will significantly improve sustained performance on a wide range of scientific applications.*

Energy Sciences Network (ESnet) Upgrade. ESnet provides unique high bandwidth networking capabilities in support of all DOE programs. A 2002 SC workshop on SC program areas identified bandwidth needs for the future, including those in climate, crystallography, high energy physics, magnetic fusion, chemical sciences, and in neutron science. Applications were identified that drove the need for a factor of 100 increase in network bandwidth over the next decade. Examples include real-time analysis of magnetic fusion experiments for adaptive control, multi-disciplinary climate models for greatly increased accuracy, remote operation and real-time visualization of imaging instruments, and distributed event analysis for high energy physics experiments. Together with other projected needs and addressing reliability

requirements, ESnet will employ new architecture and new services for the future. We will deploy advanced middleware services in support of distributed science applications, enabling multi-disciplinary modeling for complex phenomena and collaborative access to major DOE science facilities. The ESnet upgrade will include a new network architecture to increase the bandwidth and reliability of DOE Laboratory networking, and to provide high-speed peering with major collaborators. *Ultimately, ESnet will deploy new "bandwidth corridors" reinforcing a nationwide supercomputing infrastructure.*

Other Department of Energy Programs

Energy Efficiency and Renewable Energy and Electric Transmission and Distribution. The National Academy of Sciences, in its 2002 assessment of the impacts of federal R&D on energy efficiency, attributed $23 out of the $30 billion of identifiable savings to the nation from Berkeley Lab's windows and lighting research. In the future, major research areas will continue to be (1) energy efficiency in buildings, with an emphasis on windows, lighting, air infiltration, and whole commercial buildings research; (2) analysis of national and international energy issues, with an emphasis on energy use and efficiency including energy efficiency standards; (3) indoor environmental research, emphasizing sources, transport, chemical transformation, fate, and human exposure of indoor air pollutants; (4) research on energy conversion and storage technologies, emphasizing advanced batteries for vehicles, low NOx combustion; and (5) electric transmission and distribution reliability. Key targets for research in the future are:

- **Water-Energy Link and Water Use Efficiency:** This involves analysis of technologies, practices, and systems for energy and water saving; assessment of economics, programs and policies.
- **Transmission Reliability:** This involves four major activities: (1) real-time monitoring and control of the electrical grid; (2) development of viable markets for electricity reliability; (3) real-time control of end use equipment; and (4) micro-grids that improve grid performance.
- **Appliance Efficiency Standards for Industrialized and Developing Countries:** This is an expansion of appliance standards analysis from the >25 products already completed for the United States to the global community (especially the EU, China, India, and Brazil).
- **Solid State Lighting:** This involves the development of light emitting diodes (including silicon based and organic) for general lighting applications.
- **Real Time Diagnostics and Controls for Commercial Buildings:** The objective is to develop, prioritize, conduct, and disseminate research that develops broad knowledge that facilitates advanced demand response technologies.
- **Fuel Cells:** The initiative has three goals: (1) to enhance understanding of state-of-the-art proton exchange fuel cell designs (including developing in situ diagnostic techniques and understanding failure mechanisms); (2) to develop new membranes for high-temperature (120°C) operation (including nanostructured and imide-imidazole architecture membranes; and (3) to develop new electrode materials (including novel catalyst layer microstructures to reduce Pt loading).

This DOE research will continue to be complemented by research supported by the State of California and industry, particularly for building technologies and electric reliability. The California Energy Commission (CEC) and DOE supports a larger role for Berkeley in projects on energy-efficient lighting, thermal distribution systems in commercial buildings, next-generation power-management user interface for office equipment, and an instrumented home energy rating and commissioning system. Major programs will address efficient building systems and "high-tech" buildings such as clean rooms and data centers. The electricity system reliability work will continue to involve co-sponsorship with DOE for the Consortium for Electric Reliability Technology Solutions (CERTS).

Civilian Radioactive Waste Management. Berkeley Lab will continue a world-leading multidisciplinary program of interrelated geoscience and geological engineering research important to the safe, long-term underground storage of high-level nuclear wastes. This research includes characterization of deep geologic formations, determination of the physical and chemical processes occurring in the repository rocks, analysis of flow and reactive transport mechanisms, and development of predictive techniques for repository performance. Coupled with ongoing basic research, Berkeley Lab's Yucca Mountain Project site characterization research was important to the administration's plan to apply for repository licensing. In addition to the licensing application, the Office of Civilian Radioactive Waste Management (OCRWM) just announced that Berkeley Lab is the lead organization for the trust area of natural barriers. The Laboratory continues to contribute to international radioactive waste management projects in cooperation with Sweden, Switzerland, Canada, and Japan, and regularly hosts international meetings on the latest advances on repository research. *In the future, the new OCRWM-Berkeley Lab program, with strong underpinning through the Office of Science developed capabilities, will provide further an underlying technical understanding for the long-term stewardship of the nation's civilian radioactive wastes and enhance potential nuclear energy utilization worldwide through safe waste disposal.*

Fossil Energy. Fossil Energy research will be directed toward making petroleum more accessible and coal more usable. The coal research will include new catalytic processes for the sequestration of carbon dioxide and the simultaneous catalytic reduction of nitrogen dioxide and sulfur dioxide from flue gas. Oil and gas research will advance technologies to increase production or to decrease the uncertainties and costs for drilling new exploration and production wells. Underground imaging research related heat and mass transport in the crust, including reservoir dynamics will be key to increasing oil and gas production. Advances will be accomplished through the use of subsurface imaging, modeling, measurement and scaling of multiphase flow processes. Research will continue on the effects of petroleum production and refining activities on air quality, particularly on understanding and being able to predict the concentration of fine-grained, air-borne particulates. Determining the indoor concentrations of outdoor pollutants that have entered a building is also crucial for the future health risks.

Homeland Security Research. Berkeley Lab will utilize its specialized scientific and engineering capabilities to conduct unclassified research for homeland security and defense. Through integrated analysis capability and regular interaction with relevant government agencies and the Homeland Security R&D community, Berkeley Lab will identify science and technologies for improving threat reduction and consequence mitigation. The Laboratory will continue to support state and local organizations so that the actual needs of local stakeholders and groups in municipalities will have impact on technology development. Some of the science Berkeley Lab will offers for this national need are: aerosol transport modeling, compact neutron sources for non-invasive container inspection, environmental characterization for threat agents, forensics and diagnostic analysis, structural biology of microbes, advanced information technology for cyber-security, infrastructure protection, and ultra-sensitive detectors. For example, hand held gas and fluid detectors being developed for trace amounts of bacteria and chemicals will help maintain the security of wells, rivers, and airports.

National Institutes of Health and Work for Others

Berkeley Lab has many unique scientific capabilities and facilities that will continue to be made available to other government agencies, universities, and industry in support of DOE missions. DOE Biological and Environmental Research and Basic Energy Sciences facilities are of especially great value to the National Institutes of Health, which sponsors the largest share of work for others research at Berkeley Lab. Recently the NIH has joined the Office of Biological and Environmental Research (OBER) in supporting a new x-ray tomography beamline at the Advanced Light Source, that will be the only dedicated beamline of its type in the world. We anticipate that NIH research will grow, including the partnership with the National Cancer Institute, as noted in the OBER section.

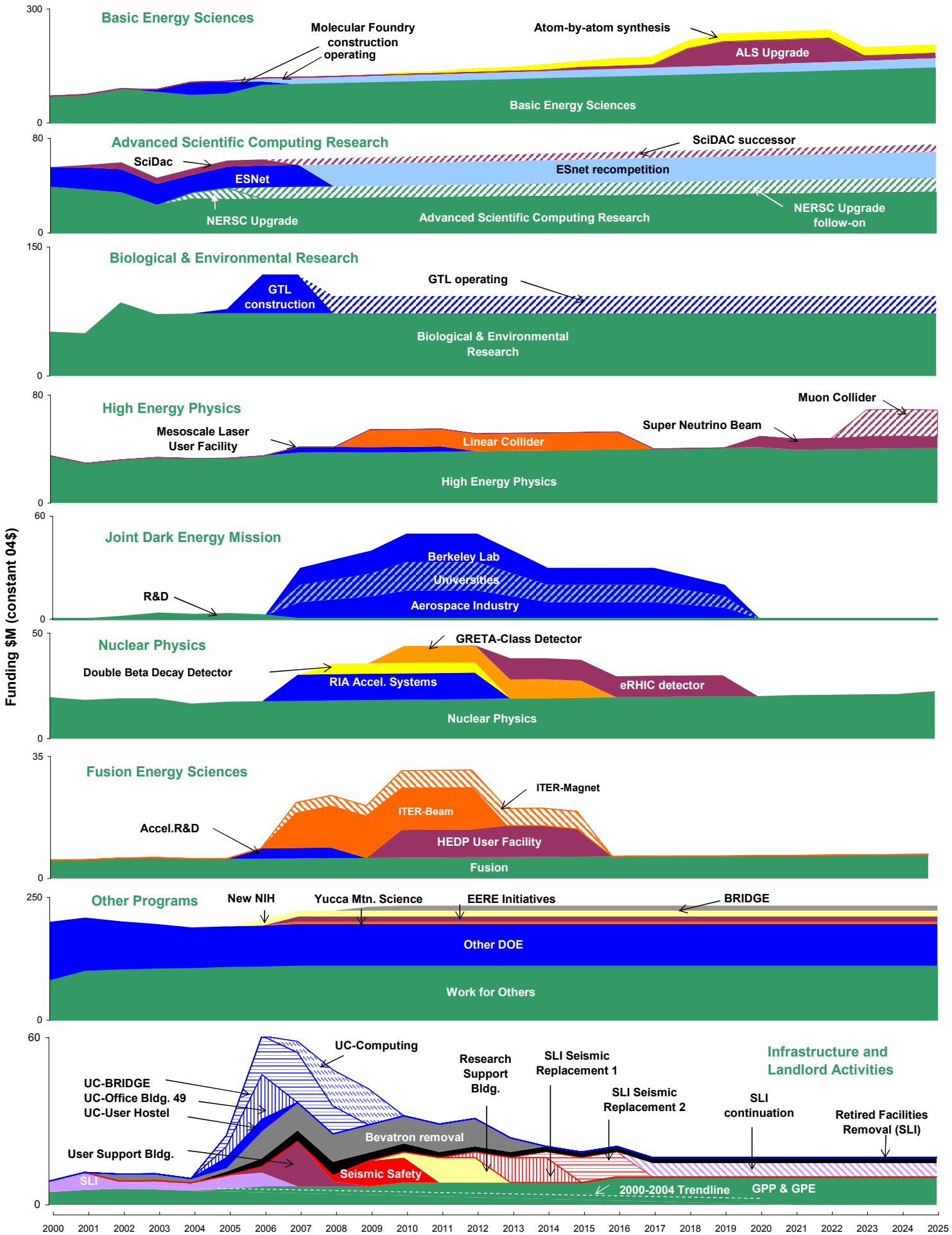
Laboratory Operations for the Future

To execute our research agenda, Laboratory operations will provide the infrastructure and administrative systems for the safe and efficient conduct of our programs. Several key operations directions to strengthen our future are:

- **Cyber Security:** Automated cyber security protection systems will monitor networks for inappropriate activity and automatically respond to threats and identify sources, while keeping the Laboratory open as a vital scientific institution. Berkeley Lab's model cyber security systems will lead to further DOE research investments with expected broader applications to other government sites.
- **Safety and Environmental Protection:** Emphasis on safety conduct has taken the Laboratory to substantially lower levels of OSHA recordable accidents (less than one half of last year's rate) and DART accidents (nearly one fourth of last year's rate). Future advances to sustain and improve on these reductions will be achieved by additional management attention to every accident.
- **Engineering.** Tight budgets require a careful assessment of the SC laboratory system engineering capabilities. Berkeley Lab will work with SC and other laboratories for a system-wide solution to address engineering needs that complement the anticipated requirements of SC programs.
- **Infrastructure.** Bevatron deconstruction progress has been achieved through removal of the External Particle Beam Hall, but significantly expanded resources are required for full deconstruction. Commencing the User Support Building construction in FY 2006, rather than FY 2007, will substantially enhance the scientific output of Berkeley Lab's user facilities. UC is working to develop third-party financing for critically needed offices, user dormitories, computing, and biological science facilities.
- **Workforce Development and Diversity.** Every Berkeley Lab employee will have a long term development plan with an annual improvement and training component. Succession planning for leadership will become the institutional norm. Our outreach efforts will enrich the workforce.
- **Accountability**. Berkeley Lab will continue to take concrete steps to further enhance business systems for greater accountability. This includes improvements in accounting, purchasing and receiving systems, and property management.
- **Effective Community Relationships**. Berkeley Lab will continue to foster constructive relationships with the community and to engage in proactive corporate citizenship.

Achieving Berkeley Lab's Vision is a part of the Operations strategic planning effort to provide cost-effective, accountable support for science. Strong engineering capabilities and modern facilities and computing and communications infrastructure are essential to advance the SC *Facilities for the Future of Science*.

Appendix A. Lawrence Berkeley National Laboratory Budget Scenario 2000 to 2025



These profiles are for long-range planning purposes only and do not represent agency commitments.